Conserving a Sea of Shadow and Substance*: Should There be a Moratorium on Harvesting Twilight Zone Fish?

Sally Dowd[1] and Porter Hoagland[2]
[1]UC Berkeley, WHOI Summer Student Fellow [2]WHOI Marine Policy Center

*Paraphrasing Rod Serling, who famously called the Twilight Zone: "..a land of shadow and substance…"


Lanternfish (Myctophidae)
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Introduction

- Fish in the ocean's mesopelagic zone or the "twilight zone" (200-1000m), are now thought to be highly abundant.
- Apex predators from the surface waters consume mesopelagic fish.
- Countries such as Norway have begun exploring the potential harvest of mesopelagic fish to supply fishmeal and fish oil markets.
- The Pacific Fisheries Management Council (PFMC) imposed a moratorium off of the U.S. West Coast on the harvest of mesopelagic fishes, such as species of lanternfish.
- This study adapted a bioeconomic decision model to examine the tradeoffs between the potential values to be gained from a hypothetical U.S. West Coast mesopelagic fishery with the potential values to be lost from declines in predators of mesopelagic fish facing a smaller prey resource.

Methods

- An economic model for forage fish developed by Hannesson, Herrick, and Field (2009) was adapted to model mesopelagic fish.
- A choice of whether to harvest mesopelagic fish can be modeled as:

$$P_s > \sum_{i=1}^{N} P_i\, a_i b_i + \nu \sum_{j=1}^{M} b_j\, a_j$$

- Biological parameters for mesopelagic fish predators were obtained from an Ecopath model based in the California Current system developed by Koehn et al. (2016).
- Ranges of the economic values of the predators ($/lb) were obtained from NOAA's annual landings data during 2006-2016.


Bristlemouths (Gonostomatidae)
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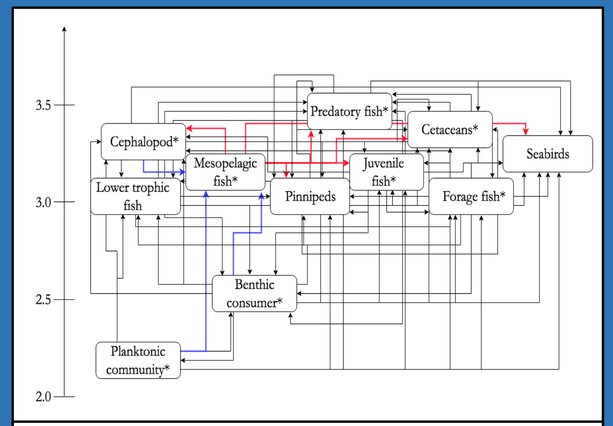

Figure 1: Food web of groups interacting in California Current with organisms originating from Koehn et al. (2016). Red arrows: predators of mesopelagic fish, blue arrows: prey of mesopelagic fish, *: groups that feed within their own group.

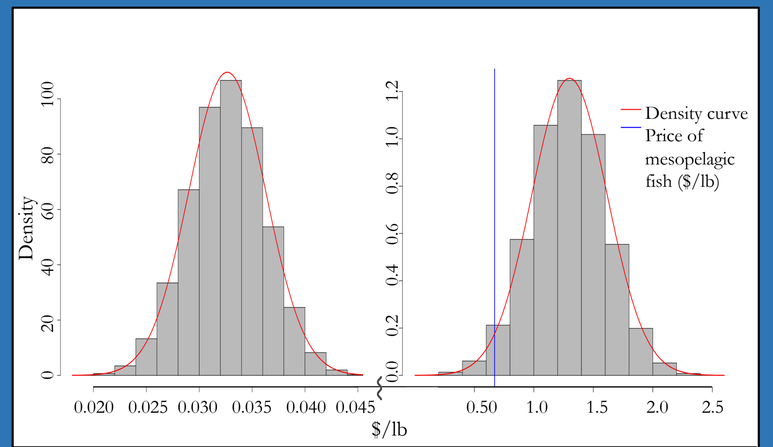

Figure 2: Histogram simulating the uncertainty around the forage value of mesopelagic fish. Distributions were analyzed for the prices of the predators and the critical value. The first distribution shows only the value of commercial predators whereas the second shows the addition of non-commercial predators (forage value of fish). The critical values for non-commercial predators were obtained through willingness-to-pay inputs.

Results

- Using commercial value data from 2016, a critical value (ν) for non-commercial predators of ~$16.00/lb was calculated.
- ν implies that, if mesopelagic fish were not harvested, then each year non-commercial predators would generate $16.00/lb in nonmarket demand
- We compared the critical value with estimates of willingness-to-pay (WTP) per lb for non-commercial predators (Table 1).
- We used a Monte Carlo approach to assess the uncertainty around input parameters to look at variation in and compare the value between commercial predators and the forage value of mesopelagic fish (Fig 2).

WTP source	Species	WTP/lb
Hageman (1985)	Bottlenose dolphin	1127
Boxall et al. (2012)	Harbor seals, lower estimate	237
Lew et al. (2010)	Stellar sea lion lower limit	64
Hageman (1985)	N. elephant seals	1

Table 1: WTP/lb of selected predators of mesopelagic fish. Dividing the total WTP by total weight of the predator stock resulted in WTP/lb.

Discussion

- When considering only the potential lost values of commercial predators (1st distribution in Fig. 2), we found that a moratorium on mesopelagic fish may not be justified from an economic perspective.
- When hypothetical lost values of non-commercial predators were also considered, a moratorium could be justified.
- Although there is uncertainty surrounding the parameters in the models, it is essential to approach this question from both ecological and economic perspectives.

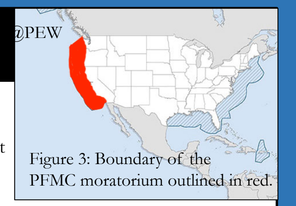

Figure 3: Boundary of the PFMC moratorium outlined in red.

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